RACAL
MODULATION METER
TYPE 409

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(continued)

PART 1

TECHNICAL SPECIFICATION

F.M. MEASUREMENT

Carrier Frequency Range	3 - 1500MHz
Deviation Ranges	Positive or negative deviation of the peak frequency from the mean carrier frequency is indicated on the meter in the following 6 ranges:-

0 - 3kHz	0 - 100kHz
0 - 10kHz	0 - 300kHz
0 - 30kHz	0 - 600kHz

Accuracy

Better than ±5% of f.s.d. for modulating frequencies from 10Hz - 50kHz. (For measurement of deviation below 40kHz an input level +10dB on SET LEVEL is required).

A.M. Rejection

When measuring F.M. on A.M. signals the errors due to unsuppressed A.M. with an input of 50mV are:-

Modulation Frequency	AM	Spurious FM
30Hz - 1kHz	50%	Less than 150Hz
30Hz - 1kHz	80%	Less than 200Hz
10kHz	50%	Less than 400Hz
15kHz	50%	Less than 500Hz

Inherent Noise

(1) With noise filter switched in the deviation due to noise is more than 46dB below 3kHz for a bandwidth of 300Hz - 3kHz.

(2) With noise filter switched out the deviation due to noise is more than 36dB below 3kHz for a bandwidth of 10Hz - 50kHz.

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F.M. MEASUREMENT (Continued)

F.M. Calibrator	A Calibrator is incorporated providing a standard squarewave deviation of ±10kHz with an accuracy of ±1%. The circuit is such that the calibrator deviation limits can be checked by means of an electronic counter.

A.M. MEASUREMENT

Carrier Frequency Range	3 - 1200MHz
Modulation Depth Ranges	Measurement of both peak and trough modulation relative to the mean carrier level is provided in three meter ranges with full scale deflections of 10%, 30% and 100% modulation.
Accuracy	Better than ±3% f.s.d. from 30Hz to 5kHz Better than ±5% f.s.d. from 10Hz to 20kHz.
Mean Carrier Level	Changes in mean carrier level on application of modulation can be measured to an accuracy or better than 1%

R.F. INPUT

Sensitivity	Better than 7mV from 3 - 300MHz Better than 20mV from 300 - 600MHz Better than 50mV from 600 - 900MHz Better than 100mV from 900 - 1500MHz
Maximum Input	Up to 10V on FM Up to 700mV on AM
Input Impedance	50Ω nominal
Attenuated Input	A second input socket provides 20dB of attenuation.

LOCAL OSCILLATOR

Frequency Ranges	8 Switched bands calibrated at the local oscillator frequency:- 3 - 6MHz 6 - 12MHz 12 - 24MHz 24 - 48MHz 48 - 90MHz 90 - 165MHz 165 - 300MHz 300 - 600MHz Frequency from 600 to 1500MHz are obtained from harmonics of 300 - 600MHz range.
Fine Tuning Control	A fine tuning control is provided for ease of use at very high frequencies
Calibration Accuracy	±3% with fine tuning control at zero.
Crystal Operation	Provision is made for using an external crystal controlled oscillator if required.

MONITOR OUTPUTS

Both L.F. (10Hz - 50kHz with switched 300Hz - 3kHz filter) and I.F. (1MHz) are available from terminals on the front panel. The output levels are approximately 1V r.m.s. when the meter reads f.s.d.

STABILISATION

Fully stabilised against mains changes of up to ±10% of the value set on the voltage selector.

POWER

Supplies:	100 - 130V or 200 - 250V 45 - 65Hz mains
Consumption:	120VA approximately

FINISH

Case:	Blue-grey stoved textured enamel.

	Front Panel: Light grey stoved enamel.
MOUNTING	In a metal case with easily detachable top, base and sides; suitable for bench use or mounting in a standard 19" rack. Special replacement side panels for rack mounting are available as optional extras.
DIMENSIONS	17" (431mm) wide x 12.5/8" (321mm) deep x 11" (279mm) high.
WEIGHT	31lb (14kg) approximately
ACCESSORIES AVAILABLE	20dB Attenuator Pad 6415-282B 50 to 75 ohm Adaptor 6793-100C 50 to 60 ohm Adaptor 6793 - 100F Rack Mounting Kit 209-4105

SECTION 1

INTRODUCTION

1.1 The Modulation Meter Type 409 is a wide range, highly sensitive instrument designed to measure percentage amplitude modulation (a.m.) of carriers from 3 - 1200MHz, and frequency deviation (f.m.) on carriers from 3 - 1500MHz. The meter scales are 0 - 10%, 0 - 30% and 0 - 100% a.m. and 0 - 3kHz, 0 - 10kHz, 0 - 30kHz, 0 - 100kHz, 0 - 300kHz and 0 - 600kHz deviation. Outputs at the intermediate frequency (nominally 1MHz) and at l.f. are available at front panel terminals and an in-built, switched noise filter permits measurement of very narrow f.m. deviations using a sensitive external l.f. millivoltmeter.

1.2 Changes in mean carrier level when a.m. is applied can be measured to better than 1% accuracy and effective i.f. limiting permits measurement of spurious f.m. on a.m.

1.3 An f.m. calibrator circuit, which can be checked directly on an electronic counter, is provided within the instrument to enable periodical calibration to be carried out. Tuning the instrument at very high frequencies has been simplified by the provision of a fine tuning control and a SET I.F. position on the meter switch. In this position the tuning control is simply adjusted until the meter reads to the SET I.F. mark, thus eliminating tedious peaking procedures.

1.4 The instrument is fully stabilised against changes in mains supply voltage of ±10% from the value set on the mains voltage selector. The power consumption is approximately 120 VA. The instrument is supplied in a metal case with quickly detachable top, base and sides. A rack mounting kit is available.

SECTION 2

INITIAL PREPARATION

Voltage Setting

2.1 The instrument leaves the Works with the voltage tapping panel, located on the rear panel, set for operation from 230V a.c. supply. For use at other supply voltages, reposition the plugs on the tapping panel as required. Access to this panel is obtained by removing the top cover of the instrument (para. 2.4 below).

2.2 Connect a three pin plug, suitable for the mains socket to be used, to the 3-core cable which is supplied internally connected in the instrument. The revised international power connection colour code is as follows:

Line	Brown	(previously red)
Neutral	Blue	(previously black)
Earth	Yellow/Green	(previously green)

2.3 A tilt stand is provided on the underside of the instrument. This stand is erected by lifting the instrument and pulling the stand forward.

REMOVAL OF COVERS

Top Cover

2.4 Remove the two screws at the rear of the cover and slide the cover forward.

Side Panel

2.5 Remove the small escutcheon from the hand-grip aperture (one screw). Remove the two screws from the rear of the panel and slide the panel forward.

Bottom Cover

2.6 Remove the two screws from the rear edge and slide the panel forward.

SECTION 3

OPERATING INSTRUCTIONS

OPERATION

NOTE This section comprises the switching-on procedure and a general tuning procedure for A.M., F.M., etc.; this is followed by additional information for carrying out the A.M., F.M. measurement etc. It should be borne in mind when carrying out these measurements that the R.F. sensitivity quoted in the Technical Specification is for the voltage at the input terminal with 0dB attenuation.

Switch ON and allow 20 minutes warm-up time. Check F.M. calibration (Paragraph 3.6. if required).

WARNING:- DO NOT CONNECT A SIGNAL WHICH HAS A d.c. COMPONENT OF MORE THAN 3 VOLTS OTHERWISE DAMAGE MAY RESULT

3.1. Tuning Procedure

(1) If the RF signal level is known connect it to the input socket of the appropriate sensitivity; if it is unknown connect it initially to the ATTENUATED INPUT SOCKET.

NOTE:-

For best results the RF source should be matched to the 50Ω input, particularly at the higher frequencies. However, satisfactory results will be obtained without matching provided that the required signal level is attained at the input socket.

(2) Set the MEASUREMENT control to SET LEVEL.

(3) Set the frequency range control to the appropriate range for the carrier frequency of the input signal.

(4) Set the FINE TUNING control to approximately mid position.

(5) Set the METER RANGE F.S.D. control to 100%

(6) Set the IF ATTENUATOR dB control to 0dB.

(7) Adjust the main TUNING control for a dial setting of the input signal frequency ±1MHz.

NOTE:-

The dial is calibrated for the local oscillator frequencies (or its harmonics). It may be set to 1MHz above or 1MHz below the signal frequency. However, the F.M. PEAK + position of the MEASUREMENT control indicates an increase in signal frequency and F.M. PEAK - a decrease in signal frequency relative to the carrier only when the tuning dial is set to 1MHz below the signal frequency.

(8) Adjust the TUNING controls for maximum reading on the meter, using the I.F. ATTENUATOR dB controls to maintain the meter reading at approximately 75% of f.s.d. In this level cannot be obtained reconnect the input signal to the NORMAL input socket.

(9) Adjust the I.F. ATTENUATOR dB controls for a reading of 10, i.e. at the SET LEVEL mark on the meter.

(10) Set the MEASUREMENT control to SET I.F.

(11) Adjust the TUNING control until the meter pointer coincides with the SET I.F. mark. Use of the FINE TUNING control at the high frequencies will be found an advantage. (This action ensures that the i.f. signal is exactly in the centre of the i.f. pass band and therefore the introduction of envelope distortions when measuring large FM deviations is minimised.)

The modulation meter is now correctly tuned to the input R.F. signal; the following paragraphs 3.2 - 3.4 detail the operations for measurement of A.M., carrier level and F.M.

3.2 Measurement of Amplitude Modulation

(1) Set the MEASUREMENT control to SET LEVEL and check that the meter pointer coincides with the SET LEVEL mark. If necessary readjust the rotary I.F. ATTENUATOR dB control.

(2) Set the MEASUREMENT control to A.M. PEAK or A.M. TROUGH as required.

(3) The percentage modulation is indicated on the 0-10 scale (0-100%) of the meter. If the modulation depth is less than 30%, set the METER RANGE F.S.D. control to 30% or 10% to obtain the best reading accuracy.

The effect of any residual hum modulation in the applied signal can be largely removed from the measurement and also from oscilloscope display by operation of the AF FILTER IN pushbutton. The a.f. filter introduces a response to the meter reading

which is approximately -20dB at 50Hz, -1dB from 300Hz to 15kHz and -20dB at 100kHz. In addition, weighted measurements using an external millivoltmeter at the L.F. terminal can be made with a -1dB response from 300Hz to 3kHz, -20dB at 50Hz and approximately 6dB/octave from 3kHz.

3.3 Measurement of Change of Mean Carrier Level

(1) Set the MEASUREMENT control to SET LEVEL and check that the meter pointer coincides with the SET LEVEL mark. If necessary readjust the rotary I.F. ATTENUATOR dB control.

(2) Switch off the modulation at source, on the input R.F. signal.

(3) Adjust the I.F. ATTENUATOR dB controls for a reading of 9 on the 0 - 10 scale.

(4) Apply the modulation signal. The change in mean carrier level is indicated on the meter as parts in 90 accurate to 1%.

(5) This procedure is appropriate to changes in carrier level up to 10%. If greater changes are required to be measured, set up the initial level (step 3) to a lower appropriate value.

3.4 Measurement of Frequency Modulation

NOTE:-

When measuring deviation below 40kHz the input level should be +10dB above SET LEVEL.

(1) Operate the I.F. ATTENUATOR 20dB pushbutton.

(2) Tune the instrument as described in Paragraph 3.1., ensuring, however, that only the rotary I.F. ATTENUATOR control is used in Operations (6) and (9) of that paragraph.

(3) Set the MEASUREMENT control to SET LEVEL.

(4) Adjust the rotary I.F. ATTENUATOR dB control for SET LEVEL indication on the meter.

(5) Operate the I.F. ATTENUATOR 0dB pushbutton.

(The i.f. level is increased by a factor of 10 ensuring complete amplitude limiting; the meter indicates more than f.s.d.)

(6) Set the METER RANGE F.S.D. control to 600 kHz.

(7) Set the MEASUREMENT control to F.M. PEAK + or F.M. PEAK - as required.

(8) The peak frequency deviation relative to the mean carrier frequency is indicated on the 0 - 3 scale of the meter. (The 600kHz range is obtained by multiplying the reading on the 0 - 3 scale by 2.)

(9) If the deviation is below 300kHz set the METER RANGE F.S.D. control to the range that provides the largest readable deflection.

(10) Where the deviation is known to be greater than 40kHz, and no A.M. is present, the measurement can be made without increasing the I.F. level by 20dB, and even for deviation down to 5kHz, the I.F. level needs only to be increased by approximately 10dB i.e. in operation (4) the meter need only indicate 1/3 F.S.D.

(11) When measuring small deviation frequencies the following precautions should be observed if accurate readings are to be obtained:-

(a) The A.F. FILTER must be switched IN. This has a flat response through the meter from 300Hz to 15kHz, although additional roll-off above 3kHz is provided to the L.F. output terminal for using an external meter for psophometric measurements.

(b) If the R.F. input level gives greater than F.S.D. with 20dB I.F. ATTENUATION the ATTENUATED R.F. input should be used. If, with the ATTENUATED INPUT in use, the input again gives more than F.S.D. with 20dB I.F. ATTENUATION then an external attenuator such as the Airmec 6415-282B should be used.

(c) At carrier frequencies below 12MHz the oscillator for this type of measurement should be set to 1MHz above the input signal frequency. (Note:- this will reverse the front panel F.M. PEAK + and PEAK - readings.)

(d) The tuning controls must be adjusted so that the SET I.F. is EXACT.

(e) Small deviations cannot be measured when the carrier frequency is below 4MHz.

Very small amounts of residual f.m. may be measured in the modulation range 300Hz - 3kHz by operation of the A.F. FILTER IN pushbutton and connection of a sensitive l.f. millivoltmeter to the L.F. OUTPUT terminals. The l.f. output for f.s.d. on the panel meter is approximately 1V r.m.s. and the residual noise generated in the instrument, with the a.f. filter connected, is such that measurements can be made of f.m. as low as 30Hz (i.e. -40dB on 3kHz). (See paragraph 3.8 - Turret Mounting.) The external millivoltmeter can be weighted to any chosen psophometric curve for measurements of C.C.I.R. specifications.

NOTE:-

A large meter deflection occurs when the MEASUREMENT control is set to the F.M. PEAK positions and the instrument is not tuned to a signal. This is normal and will not damage the meter as it is protected against excessive overloads. This large deflection is due to the limiters acting as high gain amplifiers and passing an unlimited noise signal to the l.f. circuits.

3.5 Monitoring Facilities

I.F. and L.F. terminals are provided on the front panel. The i.f. output is nominally 1MHz and allows the modulation envelope to be observed on an oscilloscope when the MEASUREMENT control is in the SET LEVEL or A.M. positions A true picture of the modulation envelope is not given when the MEASUREMENT control is in the F.M. positions. Under these conditions the a.g.c. circuit of the i.f. amplifier reduces the amplitude modulation of the i.f. signal.

The demodulated a.m. and f.m. signals are available at the L.F terminal when the MEASUREMENT control is set to one of the A.M. or F.M. positions respectively.

3.6 F.M. Calibrator

The f.m. measurement circuit is highly stable and should not normally require re-standardisation more frequently than at four monthly intervals. A calibrator circuit, producing a 1MHz signal with a deviation of ±10kHz ±1%, is provided and the instrument may be re-standardised without recourse to sophisticated test equipment as follows:-

(1) Switch Turret to EXT OSC and remove all signal inputs.

(2) Set the MEASUREMENT switch to F.M.+ or F.M.- as desired.

(3) Set the METER RANGE F.S.D control to 10kHz.

(4) Operate the A.F. FILTER OUT pushbutton to ensure that the A.F. filter is out of circuit.

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(5) Push in the PRESS TO SET 10kHz F.M. CAL knob and turn it to adjust the meter reading to exactly 10kHz.

NOTE:- Until the knob is pushed in there will be a random reading on the meter due to input circuit noise being amplified through the i.f. circuits at full gain. Pressing in the control brings the amplitude limiters into operation as for normal F.M. measurement.

(6) If readings on F.M.+ and F.M.- are not equal within ±1% refer to paragraph 5.11.

3.7 EXTERNAL OSCILLATOR Facility

This facility is of particular use when a lower inherent noise than that stated in the specification is required. Connect the external source, which may be a crystal controlled local oscillator at a spot frequency, to the 50Ω EXT. OSCILLATOR socket. The level required is not critical but should be between 100mV and 2V r.m.s. Set the frequency control to EXTERNAL OSCILLATOR and complete the tuning and measuring procedure detailed above.

3.8 Anti-Microphonic Turret Mounting

In order to eliminate microphonic signals when measuring very low levels of f.m. the whole r.f. turret assembly is mounted on anti-vibration mountings. The turret may be used free or clamped but the former conditions will normally be necessary for low level measurements, while the latter is essential when the instrument is being transported.

To free the turret turn the star locking knob behind the frequency range control anticlockwise and to clamp the turret turn the locking knob clockwise.

3.9 Measurement of a radiated signal

The high sensitivity of the Modulation Meter often permits measurement via a loop aerial. In these circumstances, terminate the loop with a 50Ω resistor. As an example 2 turns of 20 SWG insulated wire wound on 1.5 inches (36mm) diameter are sufficient to permit measurement from a 2 watt, 480MHz transmitter output socket when a 1" (25mm) length of copper wire is inserted in the TX socket.

SECTION 4

CIRCUIT DESCRIPTION

General

4.1 With reference to Figure 1 it may be seen that the r.f. input signal and the output of the local oscillator, V3a, are fed to the mixer, VT2. The mixer provides an i.f. output at a frequency of 1MHz which is fed via a low pass filter and attenuators to a three stage i.f. amplifier, V4, V5 and V6.

4.2 The i.f. amplifier is connected to cathode follower V7a, which has three outputs. When the MEASUREMENT control is in the SET LEVEL position the output from the cathode follower V7a is fed directly to the diode voltmeter.

4.3 For amplitude modulation measurement the MEASUREMENT control is set to A.M. PEAK or A.M. TROUGH and under these conditions the i.f. output from cathode follower V7a is fed to the a.m. detector, V8a. The resultant demodulation product is then fed via cathode follower V9a, the METER RANGE F.S.D. control (SD1) and a section of the MEASUREMENT control (SC10) to the l.f. amplifier, V16 and V17. The output from V17 is then fed via cathode follower V9b to the diode voltmeter, V10a and V8b. A high pass filter may be connected at the output of V17 by operation of the A.F. FILTER IN pushbutton (SE). The inclusion of this filter considerably reduces externally generated noise and hum.

4.4 When the MEASUREMENT control is set to F.M. PEAK + or F.M. PEAK - the output from cathode follower V7a is fed to V8a and also the limiters V11 and V12. V8a provides a delayed a.g.c. voltage to the i.f. amplifier, valves V4 and V5. This limits the i.f. signal to a suitable level for the amplifier and symetrically reduces the effective amplitude modulation on the signal applied to limiter V11. Final limiting to a constant amplitude squarewave is provided by the Schmitt trigger circuit. VT7 and VT8. The output from VT8 is fed to a frequency discriminator consisting of VT3, VT4 and emitter follower output stage VT5. The demodulation products of the discriminator are fed via an i.f. filter, a switched attenuator (METER RANGE F.S.D.) and a section of the MEASUREMENT control (SC10) to the l.f. amplifier, V16 and V17. The output of the l.f. amplifier is again fed via cathode follower V9b to the diode voltmeter.

4.5 The SET I.F. positions of the MEASUREMENT control are provided to facilitate tuning. When the MEASUREMENT control is at SET I.F., the output of the discriminator is connected via SC11 and meter M1 to a 30V reference supply. The meter indicates SET I.F. when the instrument is tuned so that the i.f. signal is exactly in the centre of the i.f. pass band.

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Input, Mixing and I.F. Amplifier

4.6 The r.f. input signal is fed either directly (NORMAL INPUT) or via a 20dB resistive pad (ATTENUATED INPUT) to the emitter circuit of the mixer, VT2, where it is combined with the local oscillator output to produce an i.f. frequency of 1MHz.

4.7 The local oscillator comprises triode V3a, tuning capacitor C2a and C2b and six tank circuits mounted in a simple six range turret. A single tank circuit is provided for the 3-6MHz and 6-12MHz ranges, the fundamental being used for the lower range and the 2nd harmonic for the 6-12MHz range. A similar arrangement is provided for the 12-24MHz and 24-48MHz ranges. Separate tank circuits are provided for the remaining four ranges but harmonic frequencies are used to prevent pulling between the local oscillator and signal frequencies. The tuning dial is calibrated for the local oscillator frequency and may be set either above or below the signal frequency to obtain the i.f. of 1MHz. When carriers above 600MHz are connected, harmonic mixing takes place in VT2, enabling the acceptable carrier range to be extended to 1500MHz.

4.8 When the frequency range control is set to EXT OSCILLATOR, microswitch SF is operated, disconnecting the local oscillator and connecting the EXT OSCILLATOR INPUT to the mixer.

4.9 The output of the mixer is taken via C19 to a low pass filter L15/C16, L16/C17 and L17, which cuts off all frequencies substantially higher than the modulated intermediate frequency. From the filter the signal passes via the 0 - 30dB attenuator, RV2, to the grid of the first i.f. amplifier, V4. Additional fixed attenuation of 20dB may be switched in by SB1 and SB2.

4.10 Valves V4, V5 and V6 comprise a three stage i.f. amplifier having a bandwidth of nominally 1MHz at the -3dB points. Tuning is effected by the cores of L18, L29, L19 and L30 to provide a very flat response. The i.f. output from V6 is applied to the cathode follower V7 which provides a low impedance source for the a.m. measuring circuits.

A.M. Measurements

4.11 The MEASUREMENT control, SC, is set to A.M. PEAK or A.M. TROUGH for amplitude modulation measurements. The modulated i.f. signal at the cathode of V7 is connected to the cathode of diode V8a. The demodulation product at the anode of V8a is fed via R55, R58, C45 and R60 to the grid of cathode follower V9a. The value of resistor R116 in parallel with R55 is selected during manufacture of the instrument to give a correct audio frequency characteristic of the system in the vicinity of 15kHz. Switch Section SC5 in the A.M. positions connects a negative bias of approximately 3 volts, obtained from the 12.6 volt d.c. supply via R135, to the cathode of V8a. This enables the diode to operate in the optimum condition as a

demodulator. Switch Section SC7 in the A.M. positions connects the a.g.c. lines to earth as a.g.c. is not required when measuring amplitude modulation.

4.12 The l.f. output from the cathode of V9a is connected via RV15, the set A.M. calibration control, to the potential divider formed by R142, R143 and R144. This divider has three outputs selected by the METER RANGE F.S.D. control, SD1. The selected output is fed via the A.M. positions of SC 10 to the grid of V16. V16 and V17 comprise a conventional three stage feedback amplifier having a very flat frequency characteristic from 30Hz to 50kHz. The output from the cathode of V17a is fed direct to cathode follower V9b or via an RC/LC filter as determined by switch SE. The filter has a flat response through to the meter from 300Hz to 15kHz, although additional roll-off above 3kHz is provided to the L.F. output terminal for using an external meter for psophometric measurements.

4.13 The cathode follower V9b has two outputs. One output is fed to the diode voltmeter and the second is fed via an i.f. filter to the L.F. OUTPUT terminal on the front panel.

F.M. Measurements

4.14 The MEASUREMENT control is set to F.M. PEAK + or F.M. PEAK - for frequency modulation measurements. Under these conditions the modulated i.f. signal at V7a is fed via SC9 and RV14 to the grid of V11, the first limiter stage, and also to diode V8a. V8a provides an a.g.c. voltage fed via SC7 to V4 and V5. A delayed a.g. c. voltage is also fed via RV13 and C99 to V5, the modulation component being retained at a level set by RV13. A positive bias for V8a is obtained via SC5 from resistor R54 in the cathode circuit of V7a.

4.15 The limiter stages, V11 and V12, are designed to retain the symmetry of the i.f. signal even when the original f.m. signal is heavily amplitude modulated; diodes MR3, MR4 in the grid circuit of V12 and MR21, MR22 in the output circuit are provided for this purpose. The preset variable resistors RV6, RV8 and RV14 are adjusted for the correct output waveform. The bias for the limiter stages, at approximately 3V, is derived from the 12.5V d.c. heater line through R135. A Schmitt trigger circuit formed by VT7 and VT8 provides the final stage of limiting. The collector supply for these transistors is stabilised at nominally 12V by zener diodes MR15 and MR16.

4.16 The output from VT8 is a squarewave at i.f. frequency and is fed to the frequency discriminator consisting of VT3 and VT4. In this circuit C57 is charged and discharged between defined limits, the resultant current pulses in VT4 being integrated to give an l.f. output proportional to frequency deviation. The modulation signal appearing at the output of the i.f. filter, L4, L5, C59, is fed via emitter follower VT5 and RV9 to the potential divider R91 - R94 and R127. This divider has five outputs selected by the METER RANGE F.S.D. control, SD2. Variable resistor RV9 is operated by the control "PRESS TO SET F.M. 10kHz CAL," which operates both the potentiometer and a switch when the knob is pushed in, thus providing adjustment for calibration of the instrument for f.m. measurement.

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SECTION 5

MAINTENANCE

General

5.1 Figures 4 and 5 illustrate the locations of the major components and the Component List in Section 6 provides the necessary information for component replacement. It is recommended that only the component types specified should be used.

Fault Finding

5.2 A fault within the equipment may be readily localised to a particular circuit by use of the MEASUREMENT control. Table 1 at the end of this section gives typical d.c. voltages at the valves and transistors for correct operation of the instrument.

Preset Controls

5.3 The preset controls are adjusted during manufacture to enable the instrument to meet the specified accuracy. However, one or more presets may be necessary if a component, particularly a valve or transistor, is replaced. If there is any doubt regarding the accuracy of the instrument we recommend that it is returned to the manufacturer or authorised repair depot for recalibration. Adjustment procedures are provided below but these shouldonly be attempted when accurate test equipment is available.

NOTE:-

When carrying out the following adjustment procedures the frequency range control must be set to EXTERNAL OSCILLATOR except where stated otherwise.

Adjustment of RV1

5.4 RV1 controlsthe heater voltage to V10 and V8 and sets the electrical zero of the meter. When these valves have aged, or have been replaced, it may be necessary to reset the electrical zero. Disconnect the input signal and set the MEASUREMENT control to A.M. PEAK. Adjust RV1 for zero reading on the meter. Set the MEASUREMENT control to A.M. TROUGH and check that the meter is again zero.

Adjustment of RV10.

5.5 RV10 is adjusted to set the heater voltage of V5 and V16 to 6.3V. This preset control may require adjustment if V8, V10, V5 or V16 is replaced.

Adjustment of RV5

5.6 Preset variable resistor RV5 is adjusted for equal meter readings when measuring A.M. PEAK and A.M TROUGH with a symetrically modulated signal applied to the instrument. The adjustment of this component should be checked if valves V8, V9 or V10 are replaced. The procedure detailed below should be followed.

(1) Disconnect C89 from switch SE1 and operate A.F. FILTER IN.

(2) Set the MEASUREMENT control to A.M. PEAK.

(3) Connect a balanced 1kHz signal via a 0.1μF 350V capacitor between the pole of switch SE1 and earth, and adjust the input level to obtain full-scale deflection on the meter.

(4) Reverse the 1kHz input connections to the instrument and set the MEASUREMENT control to A.M. TROUGH. Check that the instrument again indicates f.s.d.

(5) If the meter indication is not f.s.d. repeat steps (3) and (4), adjusting RV5 until the meter is f.s.d. under both conditions.

(6) Remove the 0.1μF capacitor and reconnect C89 to SE1.

Alignment of the I.F. Amplifier

5.7 The alignment of the I.F. Amplifier should be checked if a component of this circuit is replaced.

(1) Set the MEASUREMENT control to SET LEVEL.

(2) Set the I.F. ATTENUATOR dB controls to MINIMUM attenuation.

(3) Check that potentiometer RV13 is set approximately to the mid-point of its travel.

(4) Temporarily remove the core of L19.

(5) Unscrew the core of L18 until the top comes level with the upper face of the can.

(6) Screw in the core of L30 until approximately ½inch (12 mm) of thread is visible. This will be the final position of this core.

(7) Set a signal generator to 1MHz with an output level of 5mV. Connect the output to L15 at the junction of R72 (1.2kΩ) and the coaxial cable.

(8) Adjust the core of L29 for a maximum reading on the 409 meter. If necessary, resistor R180 (in parallel with L18) may be temporarily disconnected to facilitate tuning.

(9) Set the signal generator frequency to 1.5MHz.

(10) Insert the core of L19 and screw in until a peak is observed on the 409 meter; adjust the core accurately to maximise this peak.

(11) Set the signal generator to 1MHz and adjust its output level to obtain a reading of 90 on the 409 meter. Maintain this level for the next check.

(12) Set the signal generator to 460 kHz and adjust the core of L18 to give an indication of 63 on the 409 meter.

(13) Set the signal generator frequency to 1MHz and connect the output to the grid of V4 (at the junction of C27/R28/R29).

(14) Adjust the signal generator output to obtain a full-scale reading on the 409 meter. Check that the generator output level does not exceed 3mV.

Adjustment of RV3, RV6, RV13 and RV14

5.8 RV3, RV6, RV8, RV13 and RV14 are provided to enable various circuits to be adjusted to ensure that any amplitude modulation on an F.M. signal has no effect on the measurement of deviation and also to eliminate any externally generated noise from the measurement. If a component of the I.F. Amplifier or the limiter circuits is replaced the following checks should be made.

(1) Connect a 1MHz signal, amplitude modulated at 1kHz and 50%, to the NORMAL INPUT socket.

(2) Connect an oscilloscope to the I.F. OUTPUT and EARTH terminals.

(3) Set the MEASUREMENT control to SET LEVEL, the I.F. ATTENUATOR dB controls to 0dB, and Frequency Range control to EXTERNAL OSCILLATOR.

(4) Adjust the input signal level for f.s.d. on the instrument meter (SET LEVEL).

(5) Increase the level of the input signal by 20dB.

(6) Set the MEASUREMENT control to F.M. PEAK + and the METER RANGE F.S.D. to 3 kHz 10%.

(7) Adjust RV13 until the I.F. waveform has a minimum peak to trough ratio without tendency to parasitic oscillations. Switch the MEASUREMENT control to SET LEVEL and back again to F.M. PEAK +. If parasitic oscillations are seen to begin but immediately die away, re-adjust RV13 until the waveform is immediately stable. The peak to trough ratio should not be greater than 1.4:1.

(8) Using a low-capacitance probe connect the oscilloscope to the junction MR21/MR22/C56/C106 in the output circuit of the limiters.

(9) Remove the modulation from the signal and with the signal level still at +20dB on SET LEVEL and adjust RV6, RV8 and RV14 for squarest response and 1:1 mark-space ratio. RV6, RV8 and RV14 are interdependent and have similar effect on the waveform. With RV6 and RV8 at their mid-positions adjust RV14 so that the rise and fall of the squarewave are of similar gradient. Adjust RV6 as much as possible to obtain equal mark-space without radically altering the gradients. The pattern RV14-RV6-RV14-RV8-RV14-RV6....... should be carried out in small movements until the squarest response with 1:1 mark-space ratio is obtained.

(10) Connect an oscilloscope to the L.F. OUTPUT and EARTH terminals.

(11) If there is no 50Hz or 100Hz component observed on the waveform RV3 should be left in its mid-position. Otherwise adjust RV3 for minimum peak hum amplitude. Should the waveform be composed mainly of mains or hum frequency and adjustment of RV3 has no effect, then either the 1MHz input signal has spurious f.m. or a fault exists in the equipment.

(12) Check that the meter indication is less than 50Hz.

(13) Modulate the input signal to a depth of 80% with a 1kHz signal and check that the meter indication is less than 200Hz. Ensure that the signal generator used has less than 200Hz incidental f.m.

Adjustment of RV15

5.9 The accuracy of A.M. measurements are determined by the adjustment of RV15. This variable resistor may require adjustment if a component of the L.F. amplifier or meter circuit is replaced.

(1) Set the MEASUREMENT control to SET LEVEL

(2) Connect a 1MHz signal, symmetrically modulated at 1kHz to a depth of 50%, to the NORMAL INPUT.

(3) Adjust the input level to obtain SET LEVEL.

(4) Switch to A.M. PEAK and check that 50% is indicated on the meter. If necessary, adjust RV15 to obtain 50%.

Adjustment of RV12

5.10 RV12 controls the meter indication when the MEASUREMENT control is in the SET I.F. position. This control may require adjustment if a component on the i.f. amplifier or the f.m. measuring circuits is replaced.

(1) Connect a 1MHz signal to the NORMAL INPUT.

(2) Set the MEASUREMENT control to SET LEVEL and adjust the input level for f.s.d. on the meter.

(3) Set the MEASUREMENT control to SET I.F. If necessary adjust RV12 until the meter indicates SET I.F.

Adjustment of the Preset Components of the F.M. Calibrator

5.11 NOTE: It is necessary first to ensure that the meter diodes are balanced and RV5 is correctly set. See Paras. 5.1 and 5.6.

(1) Connect an oscilloscope to the L.F. OUTPUT and a Counter to the stand-off terminal post adjacent to tag strips holding VT6 and associated components (See Fig. 5).

(2) Set the MEASUREMENT switch to F.M. PEAK + or F.M. PEAK - and operate A.F. FILTER OUT. The PRESS TO SET 10kHz F.M. CAL. control must be held pushed in for the following tests. A small flag is provided for this purpose and is accessible from the right hand side of the instrument. The switch should be pushed fully in and the flag lifted to hold the switch in this position.

(3) Adjust RV11 until the relay RLA ceases to operate and the l.f. square-wave output disappears.

(4) On the transistor VT9 temporarily short-circuit the base to the emitter to open the contacts of relay RLA.

(5) Adjust capacitor C93 to obtain a Counter readout of nominally 1.0100MHz Record the actual readout obtained.

(6) Remove the base-emitter short-circuit from VT9 and adjust capacitor C94 to obtain a counter readout exactly 20kHz less than that recorded in (5).

(7) Briefly short-circuit VT9 base-emitter again and check that the counter indicates the same readout as recorded in (5). If necessary repeat steps (4) (5) and (6). Finally ensure that the short-circuit is removed from VT9.

(8) Adjust potentiometer RV11 until the counter indicates exactly 10kHz less than the readout recorded in (5).

(9) Remove the Counter test lead and check that the panel meter readings on F.M. + and F.M. - are within 1% of each other; a slight readjustment of RV11 is permitted.

(10) Finally adjust the F.M. CAL. control to set the panel meter reading to exactly 10kHz.

(11) Unlock the F.M. CAL. switch by releasing the metal flag before replacing the instrument covers.

R.F. Alignment

5.12 Replacement of the oscillator valve V3a should have little effect on the tuning dial calibration. If it is necessary to correct the calibration the procedure detailed below should be followed:-

(1) Connect a 3MHz signal at a level of 100mV to the NORMAL INPUT.

(2) Connect an oscilloscope to the junction of L17 and SB1.

(3) Set the FINE TUNING control to mid travel and the tuning dial to 3MHz.

(4) Set the frequency range control to 3 - 6MHz.

(5) Adjust the core of inductor L10 until 'zero beat' is displayed on the oscilloscope.

(6) Set the tuning dial to 6MHz and adjust the frequency of the input signal to 6MHz.

(7) Adjust trimmer C10 for 'zero beat', as displayed on the oscilloscope.

(8) Repeat steps (3) to (7) until the correct settings are attained at both ends of the range.

The method of alignment detailed above is applicable to all ranges. The alignment frequencies, input levels, dial settings etc.. for each range are tabulated on next page.

R.F. ALIGNMENT FREQUENCIES

Range MHz	Frequency (MHz)		Signal Generator 201A			Adjust
	Dial	Oscillator	Frequency	Harmonic	Approx. Level	
3 - 6 (6 - 12)	3 6	3 6	3 6	First First	100mV 100mV	L10 C10
12 - 24 (24 - 48)	12 24	12 24	12 24	First First	100mV 100mV	L11 C11
48 - 90	48 90	24 45	12 22.5	Second Second	1V 1V	L12 C12
90 - 165	90 165	45 82.5	22.5 27.5	Second Third	1V Max.RF	L13 C13
165 - 300	165 300	82.5 150	27.5 30	Third Fifth	Max.RF Max.RF	L14 C14
300 - 600	300 600	75 150	25 30	Third Fifth	Max.RF Max.RF	L9 C55

TABLE 1

VOLTAGE MEASUREMENTS

From	To	Voltage Limits	Multimeter Range
V3 Pin 1	Chassis	+2V	10V DC range
V3 Pin 2	"		
V3 Pin 3	"	-1.0V	2.5V DC range
V3 Pin 4	"		2.5V DC range
V3 Pin 5	"		
V3 Pin 6	"	-7.6V	10V DC range
V3 Pin 7	"		
V3 Pin 8	"	+70V	250V DC range
V3 Pin 9	"		
V4 Pin 1	Chassis	+1.3V	2.5V DC range
V4 Pin 2	"	0V	
V4 Pin 3	"	+1.3V	2.5V DC range
V4 Pin 4	"	-13.2V	25V DC range
V4 Pin 5	"	-7.5V	10V DC range
V4 Pin 6	"	0V	
V4 Pin 7	"	+144.5V	250V DC range
V4 Pin 8	"	0V	
V4 Pin 9	"	+130V	250V DC range
V5 Pin 1	Chassis	+1.3V	2.5V DC range
V5 Pin 2	"	0V	
V5 Pin 3	"	+1.3V	2.5V DC range
V5 Pin 4	"	-6.4V	10V DC range
V5 Pin 5	"	0V	
V5 Pin 6	"	0V	
V5 Pin 7	"	+172V	250V DC range
V5 Pin 8	"	0V	
V5 Pin 9	"	+128V	250V DC range

TABLE 1

VOLTAGE MEASUREMENTS (Continued)

From	To	Voltage Limits	Multimeter Range
V6 Pin 1	Chassis	+1.8V	2.5V DC range
V6 Pin 2	"	0V	
V6 Pin 3	"	+1.8V	2.5V DC range
V6 Pin 4)	"		
V6 Pin 5)	"	6.4Va.c.	
V6 Pin 6	"	0V	
V6 Pin 7	"	+195V	250V DC range
V6 Pin 8	"	0V	
V6 Pin 9	"	+150V	250V DC range
V7 Pin 1	Chassis	+280V	500V DC range
V7 Pin 2	"	+22.2V	25V DC range
V7 Pin 3	"	+94V	100V DC range
V7 Pin 4)	"	6.3V a.c. to pin 9	10V AC range
V7 Pin 5)	"		
V7 Pin 6	"	+280V	500V DC range
V7 Pin 7	"	+22.2V	25V DC range
V7 Pin 8	"	+94V	100V DC range
V7 Pin 9	"	6.3V a.c. to pins 4 & 5	
V8 Pin 1	Chassis	-8.3V	10V DC range
V8 Pin 2	"	0V	
V8 Pin 3	"	7.5V	25V DC range
V8 Pin 4	"	-13.6V	25V DC range
V8 Pin 5	"	0V	
V8 Pin 6	"	0V	
V8 Pin 7	"	-8.3V	10V DC range
V8 Pin 8	"		
V8 Pin 9	"		

TABLE 1

VOLTAGE MEASUREMENTS (Continued)

From	To	Voltage Limits	Multimeter Range
V9 Pin 1	Chassis	+215V	500V DC range
V9 Pin 2	"	+0.9V	2.5V DC range
V9 Pin 3	"	+32V	100V DC range
V9 Pin 4)	"	6.3V a.c. to	
V9 Pin 5)	"	pin 9	
V9 Pin 6	"	+215V	500V DC range
V9 Pin 7	"		
V9 Pin 8	"	+55V	100V DC range
V9 Pin 9	"	6.3V a.c. to pins 4 & 5	10V AC range
V10 Pin 1	Chassis	0V	
V10 Pin 2	"	0V	
V10 Pin 3	"	-7.6V	10V DC range
V10 Pin 4	"	-13.6V	25V DC range
V10 Pin 5	"		
V10 Pin 6	"	0V	
V10 Pin 7	"		
V10 Pin 8	"		
V10 Pin 9	"		
V11 Pin 1	Chassis	-6.95V	10V DC range
V11 Pin 2	"	-5.0V	10V DC range
V11 Pin 3)	"		
V11 Pin 4)	"	6.4V a.c.	10V AC range
V11 Pin 5	"	+200V	250V DC range
V11 Pin 6	"	-5V	10V DC range
V11 Pin 7	"	+215V	250V DC range
V11 Pin 8	"		
V11 Pin 9			

TABLE 1

VOLTAGE MEASUREMENTS (Continued)

From	To	Voltage Limits	Multimeter Range
V12 Pin 1	Chassis	-4V	10V DC range
V12 Pin 2	"	0V	
V12 Pin 3)	"	6.3V a.c.	10V AC range
V12 Pin 4)	"		
V12 Pin 5	"	+280V	500V DC range
V12 Pin 6	"	0V	
V12 Pin 7	"	+280V	500V DC range
V12 Pin 8	"		
V12 Pin 9	"		
V16 Pin 1	Chassis	0V	
V16 Pin 2	"	0V	
V16 Pin 3	"	+1.57V	2.5V DC range
V16 Pin 4	"	-6.40V	10V DC range
V16 Pin 5	"	0V	
V16 Pin 6	"	0V	
V16 Pin 7	"	+90V	100V DC range
V16 Pin 8	"	+44V	100V DC range
V16 Pin 9	"	+1.57V	2.5V DC range
V17 Pin 1	Chassis	+215V	500V DC range
V17 Pin 2	"	0V	
V17 Pin 3	"	+115V	250V DC range
V17 Pin 4)	"	6.3V a.c.	10V AC range
V17 Pin 5)	"		
V17 Pin 6	"	+140V	250V DC range
V17 Pin 7	"	+3.0V	10V DC range
V17 Pin 8	"	+46V	100V DC range
V17 Pin 9	"	+27V	250V DC range

TABLE 1

VOLTAGE MEASUREMENTS (Continued)

From	To	Voltage Limits	Multimeter Range
V18 Pin 1	Chassis	+300V	500V DC range
V18 Pin 2	"	+297V	500V DC range
V18 Pin 3	"	+300V	500V DC range
V18 Pin 4)	"	6.4V a.c. tied	
V18 Pin 5)	"	to +300V	
V18 Pin 6	"		
V18 Pin 7	"	410V	500V DC range
V18 Pin 8	"	410V	500V DC range
V18 Pin 9	"	410V	500V DC range
V19 Pin 1	Chassis	+300V	500V DC range
V19 Pin 2	"	+297V	500V DC range
V19 Pin 3	"	+300V	500V DC range
V19 Pin 4)	"	6.4V a.c. tied	
V19 Pin 5)	"	to +300V	
V19 Pin 6	"		
V19 Pin 7	"	+410V	500V DC range
V19 Pin 8	"	+410V	500V DC range
V19 Pin 9	"	+410V	500V DC range
V20 Pin 1	Chassis	+92V	100V DC range
V20 Pin 2	"	+93V	100V DC range
V20 Pin 3)	"	6.4V a.c.	10V AC range
V20 Pin 4)	"		
V20 Pin 5	"	+297V	500V DC range
V20 Pin 6	"	+93V	100V DC range
V20 Pin 7	"	+144V	250V DC range
V20 Pin 8	"		

TABLE 1

VOLTAGE MEASUREMENTS (Continued)

From	To	Voltage Limits	Multimeter Range
V21 Pin 1	Chassis	0V	
V21 Pin 2	"	0V	
V21 Pin 3	"	0V	
V21 Pin 4	"	+93V	100V DC range
V21 Pin 5	"	+93V	100V DC range
V21 Pin 6	"	+93V	100V DC range
V21 Pin 7	"	+93V	100V DC range
V21 Pin 8	"		
V21 Pin 9	"		

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SECTION 6

LIST OF COMPONENTS

CONTENTS

LIST OF COMPONENTS

Circuit Reference	Resistance Ω	Tolerance ±%	Rating (Watts)	Type
Resistors				
R1	22	5	1/8	Erie EM1
R2	100k	5	1/8	Erie EM1
R3	330k	10	1/2	Erie 16
R4a & b	5.6k	5	16	Paignton 302A
R5	15k	10	1/2	Erie 16
R6	8.2k	5	1/4	Erie 16
R7	560	10	1/4	Erie 16
R8	3.3k	5	1/8	Erie EM1
R9	47	10	1/2	Dubilier BTT
R10	1k	10	1/2	Erie 16
R11	470	10	1/4	Erie 16
R12	22	10	1/4	Erie EM1
R13	680	10	1/4	Erie EM1
R14	100	10	1/4	Erie EM1
R15	100	10	1/2	Erie 16
R16	68k	10	1/4	Erie 16
R17	68k	5	1/8	Erie EM1
R18	4.7k	10	1	Erie RMA8
R19	470	10	1/2	Erie 16
R20	22	10	1/2	Dubilier BTT
R21	3.9k	5	1/8	Welwyn C21
R22	3.9k	5	1/8	Welwyn C21
R23	1k	5	1/8	Welwyn C21
R24	10k	10	1	Erie RMA8
R25	3.3k	10	1/2	Erie 16
R26	56	10	1/4	Erie 16
R27	22	10	1/2	Dubilier BTT
R28	100k	10	1/2	Erie 16
R29	100	10	1/2	Erie 16
R30	15k	10	1	Erie RMA8

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Circuit Reference	Resistance Ω	Tolerance ±%	Rating (Watts)	Type
<u>Resistors</u>				
R31	6.8k	5	10	Welwyn W24
R32	8.2k	10	1/2	Erie 8
R33	100k	10	1/2	Erie 16
R34	100	10	1/2	Erie 16
R35	15k	10	1/2	Erie 16
R36	100	10	1/2	Erie 16
R37	15k	10	1	Erie RMA8
R38	15k	10	1/2	Erie 16
R39	6.8k	5	10	Welwyn W24
R40	6.8k	10	1	Erie RMA8
R41	120	10	1/4	Erie 16
R42	39k	10	1/4	Erie 16
R43	100	10	1/2	Erie 16
R44	6.8k	5	10	Welwyn W24
R45	3.9k	10	1/2	Erie RMA8
R46	100	10	1/2	Erie 16
R47	100k	10	1/2	Erie 16
R48	1k	10	1/2	Erie 16
R49	1k	10	1	Erie RMA8
R50	1k	10	1/4	Erie RMA9
R51	56	10	1/2	Erie 16
R52	3.3k	5	1	Erie 10
R53	1k	10	1	Erie RMA8
R54	470	10	1/2	Erie RMA8
R55	100k	10	1/2	Erie 16
R56	47k	5	1/2	Electrosil TR5
R57	47k	10	1/2	Erie 16
R58	100k	10	1/2	Erie 16
R59	1M	10	1/2	Erie 16
R60	1k	10	1/2	Erie 16

Circuit Reference	Resistance Ω	Tolerance ±%	Rating (Watts)	Type
Resistors				
R61	56	10	1/2	Dubilier BTT
R62	330	10	1	Erie RMA8
R63	10k	10	1	Erie RMA8
R64	100k	1	1/2	Welwyn C23
R65	100k	1	1/2	Welwyn C23
R66	470	10	1/2	Dubilier BTT
R67	1k	10	1/2	Erie 16
R68	1M	10	1/2	Erie 16
R69	3.3k	2	1/8	Erie N6
R70	56	10	1/2	Dubilier BTT
R71	4.7k (AOT)	10	1/2	Erie 16
R72	1k	10	1/2	Erie 16
R73	1k	10	1/2	Erie 16
R74	10k	10	1	Erie RMA9
R75	22k	10	1	Erie RMA8
R76	3.3k	10	1	Erie RMA8
R77	10k	20	1	Erie RMA2
R78	4.7k	10	1	Erie RMA8
R79	33k	10	1	Erie RMA8
R80	33k	10	1	Erie RMA8
R81	1k	10	1/2	Erie 16
R82	33k	10	1	Erie RMA8
R83	6.8k	20	1	Erie RMA2
R84	10	10	1/4	Erie RMA9
R85	100k	10	1	Erie RMA8
R86	6.8k	10	1	Erie RMA8
R87	1k	5	1/8	Erie EM1
R88	10k	10	1/4	Erie 16
R89	Not used			
R90	7k	1	1/2	Erie MOG60

Circuit Reference	Resistance Ω	Tolerance ±%	Rating (Watts)	Type
Resistors				
R91	2k	1	1/2	Erie MOG60
R92	700	1	1/2	Erie MOG60
R93	200	1	1/2	Erie MOG60
R94	50	1	1/2	Erie MOG60
R95	1M	10	1/2	Erie 16
R96	220k	10	1/2	Erie 16
R97	10k	10	1/2	Erie 16
R98	1.5k	10	1	Erie RMA8
R99	68	2	1/8	Welwyn C20
R100	1M	10	1/2	Erie 16
R101	2.2k	10	3	Welwyn W21
R102	15k	10	1	Erie RMA8
R103	330	10	1	Erie 16
R104	39k	10	1/4	Erie 9
R105	3.9k	2	1/2	Erie MOG60
R106	330	10	1/4	Erie 16
R107	220k	10	1/2	Erie RMA 9
R108	1k	10	1/2	Erie 16
R109	1k	10	1/2	Erie 16
R110	3.3k	10	1/2	Erie 8
R111	330	10	1/4	Erie 16
R112	10k	10	1/2	Erie 16
R113	47k	10	1/2	Erie 16
R114	2.2k	10	1	Erie RMA8
R115	1.5M	10	1	Erie RMA8
R116	100k	10	1/2	Erie 16
R117	100	10	1/4	Erie RMA16
R118	22	10	1/4	Erie RMA16
R119	22	10	1/4	Erie 16
R120	22	10	1/4	Erie 16

Circuit Reference	Resistance Ω	Tolerance ±%	Rating (Watts)	Type
Resistors				
R121	22	10	1/4	Erie 16
R122	820k	10	1/4	Erie 16
R123	15k	10	1	Erie 10
R124	150k	2	1/4	Welwyn C21
R125	150k	2	1/4	Welwyn C21
R126	220k	2	1/4	Welwyn C21
R127	100k	2	1/4	Welwyn C21
R128	470	10	1/2	Erie 16
R129	470	10	1/2	Erie 16
R130	100k	10	1	Erie RMA8
R131	100k	10	1	Erie RMA8
R132	1k	10	1/2	Erie 16
R133	1k	10	1/2	Erie 16
R134	100	10	1	Erie RMA8
R135	270	10	1/2	Erie RMA8
R136	3.3k	10	1/2	Erie 16
R137	470	10	1/2	Erie 16
R138	22	10	1	Erie RMA8
R139	56	10	1	Erie RMA8
R140	3.3	10	3	Welwyn W21
R141	15k	10	1	Erie 10
R142	6.7k	1	1/2	Erie MOG60
R143	2.3k	1	1/2	Erie MOG60
R144	1k	1	1/2	Erie MOG60
R145	33k	10	1/8	Erie EM1
R146	47k	10	1/2	Erie 16
R147	560	2	1/8	Erie N6
R148	22k	2	1/8	Erie N6
R149	220k	2	1/8	Erie N6A
R150	2.2M	2	1/4	Welwyn C21

Circuit Reference	Resistance Ω	Tolerance ±%	Rating (Watts)	Type
Resistors				
R151	330	10	1/2	Erie 16
R152	1M	10	1/2	Erie 16
R153	33	20	6W	Welwyn W22
R154	10k	10	1/2	Erie 16
R155	12k	10	1/4	Erie 16
R156	1k	10	1/2	Erie 16
R157	33	10	1/2	Erie 16
R158	68k	10	1/2	Erie 16
R159	2.2k	10	1/2	Erie 16
R160	39k	10	1/4	Erie 16
R161	2.7k	10	1/4	Erie 16
R162	3.9k	10	1/4	Erie RMA8
R163	1.8k	10	1/8	Erie EM1
R164	Not used			
R165	3.3k	10	1/2	Erie 16
R166	150	10	1/2	Erie 16
R167	33 (see note)	10	1/4	Erie 16
R168	50	1	1/2	Erie MOG60
R169	1k	10	1/2	Erie 16
R170	3.3k	5	10	Welwyn W24
R171	33k	10	1	Erie RMA8
R172	33k	10	1	Erie RMA8
R173	150	10	1/2	Erie 16
R174	100	10	1/2	Erie 16
R175	Not used			
R176	47k	10	1/2	Erie 16
R177	1k	10	1/2	Erie 16
R178	22k	10	1/2	Erie 16
R179	100k	10	1/2	Erie 16
R180	10k	10	1/4	Erie 16
R181	68	10	1/2	Erie 16
R182	100	10	1/4	Erie EM1

NOTE: In some instruments R167 comprises two 68Ω resistors in parallel.

Circuit Reference	Resistance Ω	Tolerance ±%	Rating (Watts)	Type
Variable Resistors				
RV1	10 w.w. linear preset	20	1/4	Colvern CLR 901C
RV2	5k	10	3	Airmec 231/0028
RV3	270 w.w. linear preset	5	1	Reliance MW
RV4	Not used			
RV5	2.7k w.w. linear preset	5	1	Reliance MW
RV6	1k linear	20	1/4	Plessey 404/8/02856/036
RV7	50k Inverse Log			Plessey Type E
RV8	560 linear	20	1/4	Plessey 404/8/02856/Black
RV9	10k FM.(Calibration)	20	1/4	Airmec 6917-315
RV10	470 w.w. linear preset	5	1	Reliance MW
RV11	47k	20	1/4	Plessey 404/8/02856/017
RV12	100	20	1/4	Plessey 404/8/02856/014
RV13	47k	20	1/4	Plessey 404/8/02856/017
RV14	10k	20	1/4	Plessey 404/8/02856/033
RV15	330	20	1/4	Plessey 404/8/02856/Green

Circuit Reference	Capacitance F	Tolerance ±%	Rating (Volts)	Type
Capacitors				
C1	3000p	25	300	Erie K7004/811
C2	5000μ	+50-20	35	Dubilier CT4888/CT35
C3a	100μ	+50-20	350	Hunts KBQ411CT
C3b	100μ	+50-20	350	Hunts KBQ 411 CT
C4	Not used			
C5	47p	10	350	TCC SMWN

Circuit Reference	Capacitance F	Tolerance ±%	Rating (Volts)	Type
<u>Capacitors</u>				
C6	22p	10	750	Erie N750/AD
C7	Not used			
C8	22p	10	750	Erie N750/AD
C9	3000p	25	300	Erie K7004/811
C10	2 - 8p	Var.	500	Mullard E7875
C11	3 - 30p	Var.	500	Mullard E7876
C12	3 - 30p	Var.	500	Mullard E7876
C13	2 - 8p	Var.	500	Mullard E7875
C14	2 - 8p	Var.	500	Mullard E7875
C15	22p	10	750	Erie N750/AD
C16	15p	10	750	Erie N750/AD
C17	47p	10	750	Erie N750/AD
C18	.05µ	10	250	Hunts W48
C19	330p	10	500	Erie K170051/AD
C20	100 + 100p Var.	Var.	500	Airmec 6390-170
C21	47p	10	350	TCC SMWN
C22	100p	10	750	Erie N750/BD
C23	1500p	10	750	Erie K120051/BD
C24	0.1µ	20	200	Hunts W45/BD600
C25	0.1µ	25	350	Hunts W48/A337
C26	0.1µ	10	250	Hunts 301/1
C27	470p	20	500	Erie K120051/AD
C28	1.0µ	10	250	Hunts 301/1
C29	470p	20	500	Erie K120051/AD
C30	220p	20	500	Erie Hi-k/GP2/AD
C31	0.1µ	25	350	Hunts W48/A337
C32	0.1µ	10	250	Hunts 301/1
C33	220p	20	500	Erie Hi-k/GP2/AD
C34	0.1µ	25	350	Hunts W48/A337
C35	220p	20	500	Erie Hi-k/GP2/AD

Circuit Reference	Capacitance F	Tolerance ±%	Rating (Volts)	Type
Capacitors				
C36	0.1μ	25	350	Hunts W48/A337
C37	.01μ	25	350	TCC CP32N
C38	.05μ	20	350	TCC CP35N
C39	47p	10	500	Erie AD
C40	50μ	+50-10	25	Hunts MEW31T
C41	1800p	20	500	Erie Hi-k
C42	100p	10	750	Erie N750/BD
C43	10p	10	750	Erie P100/AD
C44	0.1μ	10	250	Hunts 301/1
C45	.01μ	25	350	TCC CP32N
C46	470p	20	500	Erie K120051/AD
C47	50μ	+50-10	6.4	Hunts MEW9T
C48	0.1μ	25	150	Hunts W48/A300
C49	0.1μ	25	150	Hunts W48/A300
C50	.01μ	25	500	Hunts L51
C51	0.1μ	25	350	Hunts W48/A337
C52	.01μ	25	300	Erie K7004/811
C53	.01μ	25	500	Hunts L51
C54	.01μ	25	500	Hunts L51
C55	2.8p	Var.	500	Mullard E7875
C56	.01μ	25	350	TCC CP32N
C57	56p	5	500	Erie N560/BD
C58	100p	10	750	Erie N750/BD
C59	47p	10	750	Erie N750/AD
C60	2.0μ	10	250	Hunts 301/1
C61	0.1μ	+50-25	18	Erie 811/T/18
C62a & b	32μ32μ	+50-20	350	Hunts KBQ417
C63	2000p	2.5	160	WAYCOM MIAL 611.2
C64	2000p	2.5	160	WAYCOM MIAL 611.2
C65	0.1μ	25	350	TCC CP37N

Circuit Reference	Capacitance F	Tolerance ±%	Rating (Volts)	Type
Capacitors				
C66	1000μ	+50-10	16	Mullard C437AR/E100
C67	160μ	+50-20	40	Mullard C437/AR/G160
C68	0.1μ	25	350	TCC CP37N
C69	1200p	10	500	Erie K120051/BD
C70	1500p	20	500	Erie K120051/BD
C71	25μ	+50-20	50	Hunts 1715A00
C72	1.0μ	+50-20	275	Plessey 439/1/04187/962
C73	.01μ	25	500	Hunts L51
C74	2.0μ	10	250	Hunts 301/1
C75	0.5μ	25	150	Hunts W48
C76	100μ	+100-20	6	Plessey 402/1/01207/001
C77	18p	20	750	Erie N750/AD
C78	18p	20	750	Erie N750/AD
C79	1500p	20	500	Erie K120051/BD
C80	1500p	20	500	Erie K120051/BD
C81	.05μ	20	250	Hunts L68/G109
C82	0.1μ	10	400	Waycom Tropyfol F
C83	1000p	+80-20	500	Erie K2600/361
C84	0.1μ	+50-20	12	Erie 811/T/12
C85	3000p	25	300	Erie K7004/831
C86	0.1μ	2.5	33	MIAL 611.4
C87	.01μ	2.5	160	MIAL 611.4
C88	.001μ	2.5	160	MIAL 611.2
C89	.02μ	20	150	Hunts W99/B807
C90	4700p	20	500	Erie Hi-k/K7004
C91	450p	2.5	160	WAYCOM MIAL 611.1
C92	0.1μ	+50-25	12	Erie Hi-k
C93	3-30p	Var.	500	Mullard E7876
C94	3-30p	Var.	500	Mullard E7876
C95	1.0μ	+50-20	275	Plessey 439/1/04817/962

Circuit Reference	Capacitance F	Tolerance ±%	Rating (Volts)	Type
<u>Capacitors</u>				
C96	15p	10	750	Erie N750/AX
C97	1.0μ	10	250	Hunts 301/1
C98	330p	10	500	Erie K120051/K
C99	0.1μ	10	250	Hunts 301/1
C100	560p	10	500	Erie K170051/AD
C101	150p	5	500	Erie N750/BD
C102	220p	10	500	Erie K120051/K
C103	220p	20	500	Erie Hi-k/GP2/AD
C104	150p	5	500	Erie N750/BD
C105	0.1μ	10	200	Hunts 301/1
C106	33p	10	750	Erie N750/AD
C107	220p	20	500	Erie Hi-k/GP2/AD
C108	22p	10	750	Erie N750/AD
C109	22p	10	750	Erie N750/AD
C110	160μ	+50-10	40	Mullard C437AR/G.160
C111	82p	10	750	Erie N750/AD
C112	10p	10	750	Erie P100/AD
C113	Not used			
C114	160μ	+50-10	40	Mullard C437AR/G.160
C115	Not used			
C116	1.8p	10	750	Erie P100/AD
C117 (on switch SC)	.033μF	+50-20	18	Erie 831/T/18
C118	160μ	+50-10	40	Mullard C437AR/G.160
C119	Not Used			
C120	1.0μ	10	250	Hunts 301/1
C121	1500p	+40-20	250	Erie 811/K7004
C122	100p	10	750	Erie N750/BD
C123	22μ	+50-20	350	Plessey 439/1/13521/481
C124	22μ	+50-20	350	Plessey 439/1/13521/481
C125	22p	10	500	Erie N750/AD

Circuit Reference	Capacitance F	Tolerance ±%	Rating (Volts)	Type
Capacitors				
C126	100p	10	750	Erie N750/BD
C127	1800p	20	500	Erie Hi-k/AD
C128	1200p	10	500	Erie K120051/BD
C129	2.5μ	+50-10	64	Mullard C426AR/HR-5
C130	1000p	20	500	Erie K120051/BD
C131	.02μ	20	350	TCC CP33N

Circuit Reference	Details	Type
Valves		
V1	Not used	
V2	Not used	
V3		Mullard EC1000
V4		Mullard E180F
V5		Mullard E180F
V6		Mullard E180F
V7		Brimar 12AT7 (CV455)
V8		Brimar 6AL5 (CV140)
V9		Brimar 12AT7 (CV455)
V10		Brimar 6AL5 (CV140)
V11		Brimar 6AM6 (CV138)
V12		Brimar 6AM6 (CV138)
V13	Not used	
V14	Not used	
V15	Not used	

Circuit Reference	Details	Type
Valves		
V16		Brimar 6BR7 (CV2135)
V17		Mullard 6U8
V18		Mullard EL86 (CV5094)
V19		Mullard EL86 (CV5094)
V20		Brimar 6AM6 (CV138)
V21		GTR95/M/S (CV286)
Transistors		
VT1		Mullard OC35
VT2		Mullard BFY90
VT3		Fairchild C424
VT4		Fairchild C424
VT5		Fairchild C424
VT6		Fairchild V405A
VT7		STC BSY95A
VT8		STC BSY95A
VT9		Ferranti ZTX500
Rectifiers		
MR1,2.	Not used	
MR3		Mullard OA91
MR4		Mullard OA91
MR5	Voltage Regulator 13V	STC Z3B-130F or Mullard SZ13C
MR6		Lucas DDO56
MR7		Lucas DDO56
MR8		Lucas DDO56
MR9		Lucas DDO56
MR10		Lucas DDO58

Circuit Reference	Details	Type
Rectifiers		
MR11		Lucas DDO58
MR12		Lucas DDO58
MR13		Lucas DDO58
MR14		Brush BA110
MR15	Voltage Regulator 6.2V	Mullard BZY88-C6V2
MR16	Voltage Regulator 6.2V	Mullard BZY88-C6V2
MR17	Not used	
MR18		Mullard OA47
MR19		Mullard AAZ12
MR20		Mullard BYX36-600
MR21		Mullard OA91
MR22		Mullard OA91
MR23	Voltage Regulator 18V	Mullard SZ18C
MR24		Transitron S570G
MR25	Voltage Regulator 4.7V	Mullard BZY88C4V7
MR26	Voltage Regulator 4.7V	Mullard BZY88C4V7
MR27		Mullard OA91
MR28.29.		Mullard OA91
Inductors		
L1	75μH	Airmec 6917-195
L2	Not used	
L3	66μH	Airmec 6917-196
L4	7.95μH	Airmec 6917-197
L5	2.2μH	Airmec 6917-198
L6,7,8	Not used	
L9	0.1μH	Airmec 6390-194
L10	14μH	Airmec 6390-190
L11	0.9μH	Airmec 6390-191
L12	0.22μH	Airmec 6390-192

Circuit Reference	Details	Type
Inductors		
L13	0.2μH	Airmec 6390-193
L14	0.1μH	Airmec 6390-194
L15	125μH	Airmec 6917-199
L16	500μH	Airmec 6917-201
L17	125μH	Airmec 6917-200
L18	1.27μH	Airmec 6917-202
L19	400μH	Airmec 6917-203
L20	Not used	
L21	1.5mH	Airmec 6390-136
L22	1.5mH	Airmec 6390-137
L23	Not used	
L24	Not used	
L25	90mH	Airmec 6917-312
L26	0.4μH	Airmec 6814-168
L27	0.4μH	Airmec 6814-168
L28	0.4μH	Airmec 6814-168
L29	100μH	Airmec 6917-207
L30	4.7μH	Airmec 6917-206
Transformers		
T1		Airmec 6917-271
Relay		
RLA/1		Erg MEM01-1RA/G3-6V/330Ω
Miscellaneous		
Meter	Sifam 'Director M44 100μA FSD 1040Ω	Airmec 6917-376

Circuit Reference	Details	Type
Switches		
SA	D.P. ON-OFF	Car Fastener 81/811
SB	0/20dB Attenuator	Airmec 6917-183
SC	Function Switch Assembly	Airmec 6917-382
SD	Range Switch	Airmec 6917-181
SE	A.F. Switch	Airmec 6917-183
SF	Micro-Switch (Ext OSC INPUT)	Honeywell 11SM1-T
SF1-SF4	10 kHz F.M.CAL: 4 pole: spring return	AB Electronics Type 400
Lamp		
ILP1	6.3V	Vitality 674
Fuse		
FS1	2 Amp	Belling Lee L1055/2
Connectors		
SKT1,2,3.	BNC 50 Ω Bulkhead socket	Greenpar GE35029
Rack Mounting Kit		Airmec 209-4104

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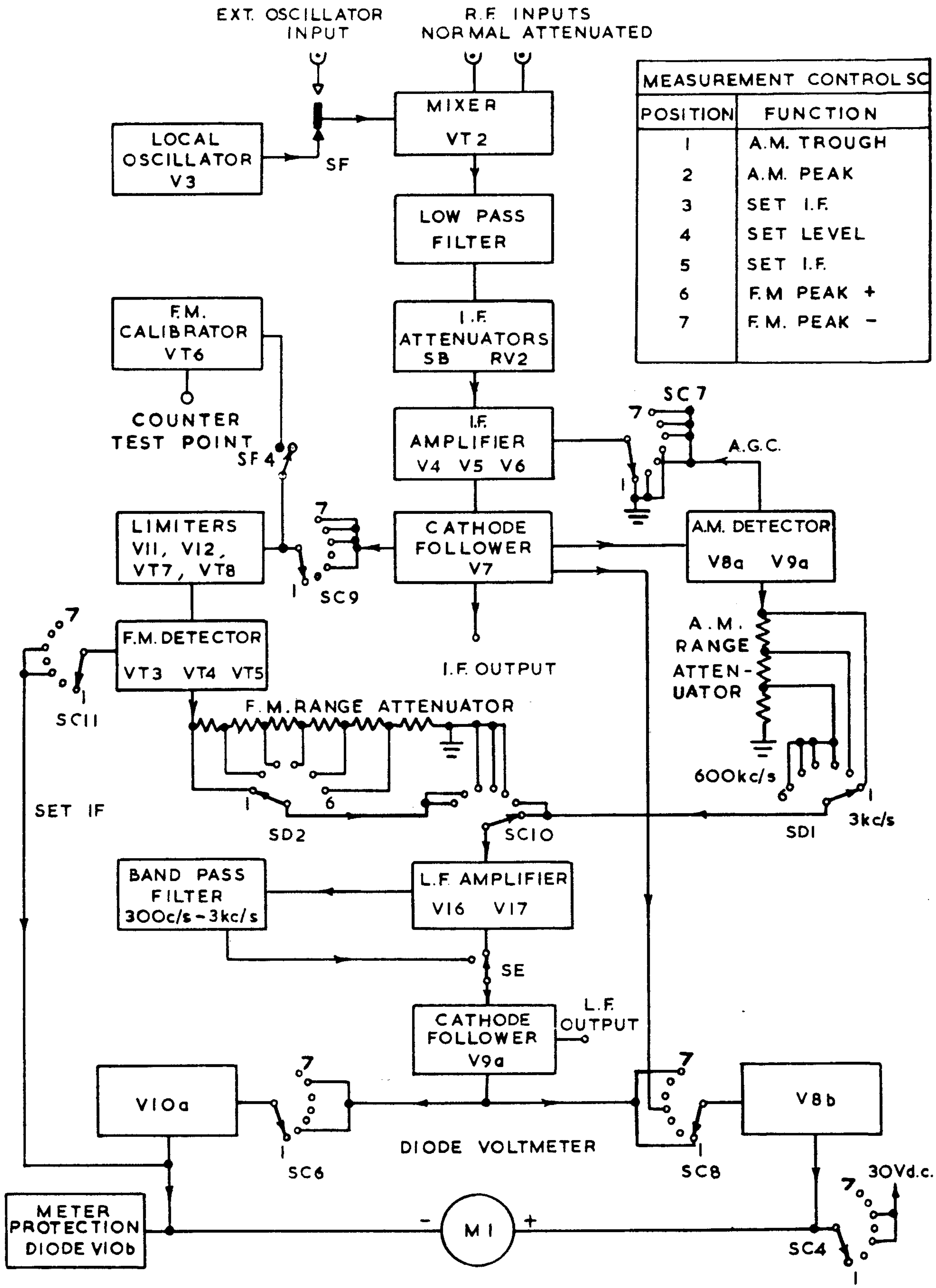
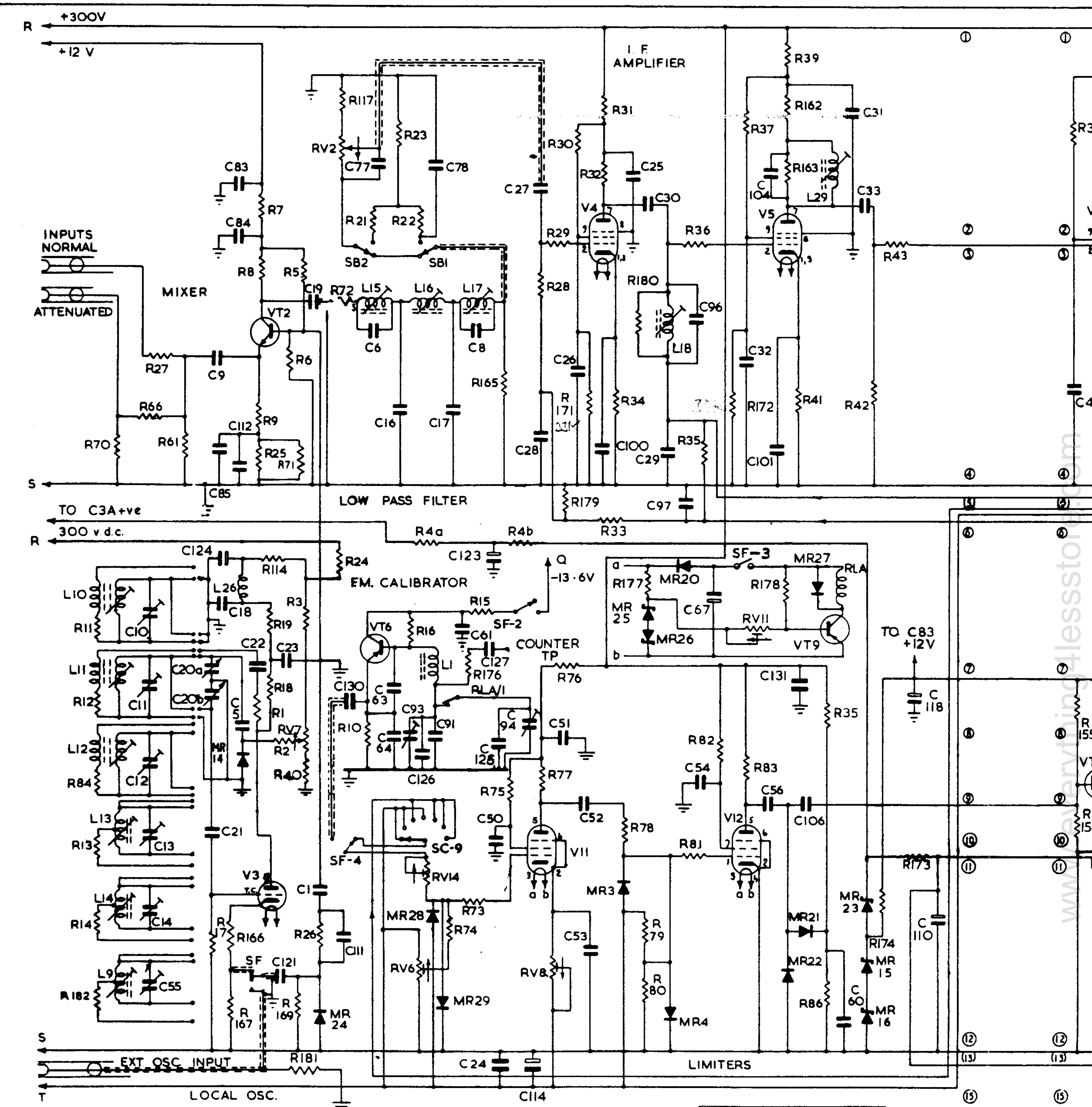
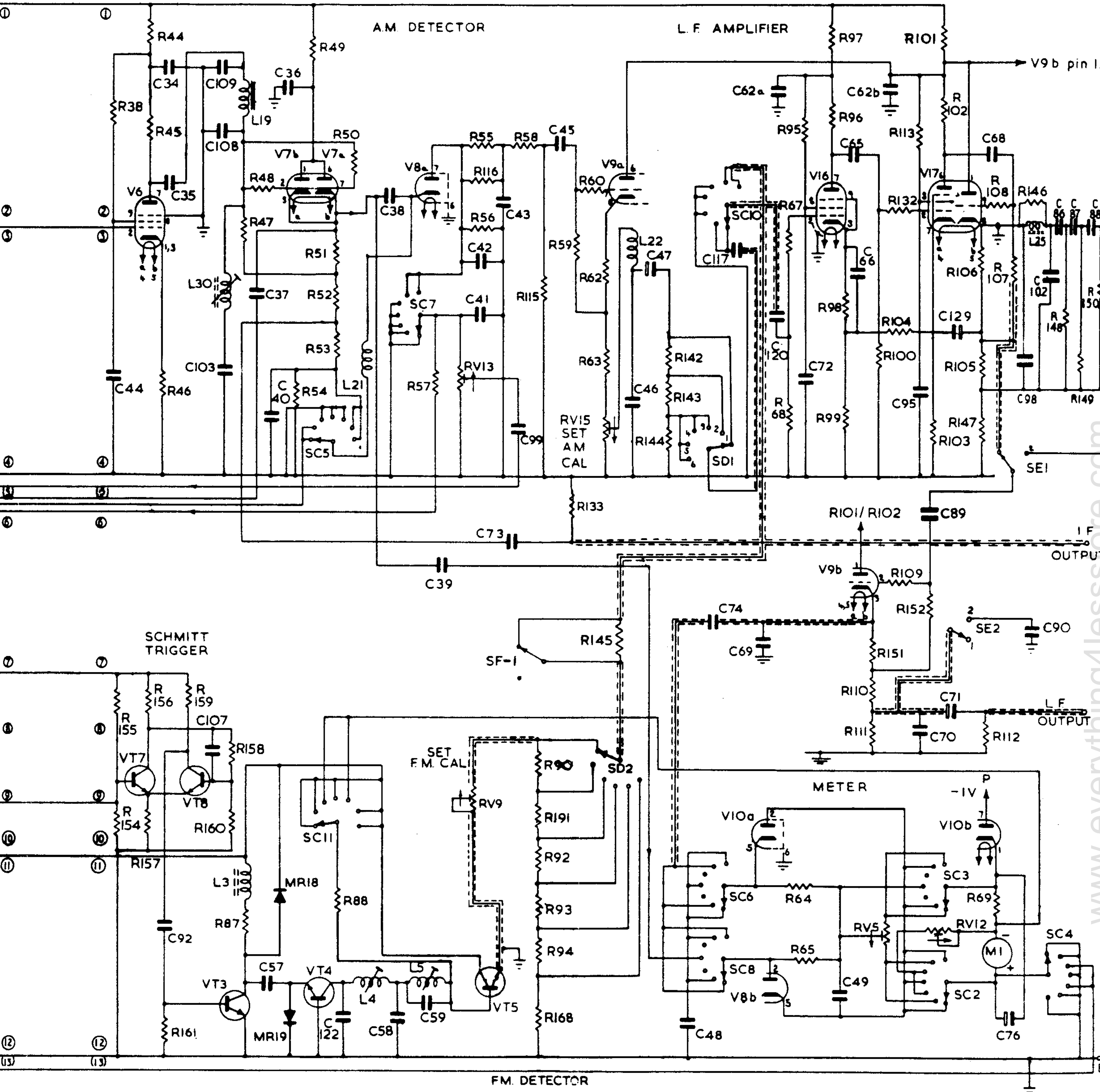


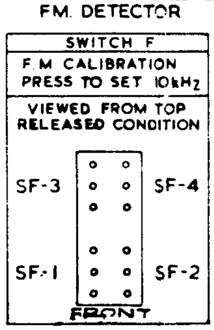
MODULATION METER TYPE 409 FIG. 1
BLOCK SCHEMATIC



COIL TURRET DATA	
RANGE	FREQUENCY
1	3 - 6 Mc/s
	6 - 12 Mc/s
2	12 - 24 Mc/s
	24 - 48 Mc/s
3	48 - 90 Mc/s
4	90 - 165 Mc/s
5	165 - 300 Mc/s
6	300 - 570 Mc/s
7	EXTERNAL OSC.
	In this position micro sw. SF is operated by the turret.-



SWITCH	POS.N	REFERENCE
SB I.F. ATTENUATOR dB	1	0 dB
	2	-20 dB
SC MEASUREMENT	1	AM TROUGH
	2	AM PEAK
	3	SET I.F.
	4	SET LEVEL
	5	SET I.F.
	6	FM + VE PEAK
	7	FM - VE PEAK
SD METER RANGE F.S.D.	1	0-3 kc/s 0-10%
	2	0-10 kc/s 0-30%
	3	0-30 kc/s 0-100%
	4	0-100 kc/s
	5	0-300 kc/s
	6	0-600 kc/s
SE A.F. FILTER 300c/s - 3kc/s	1	OUT
	2	IN

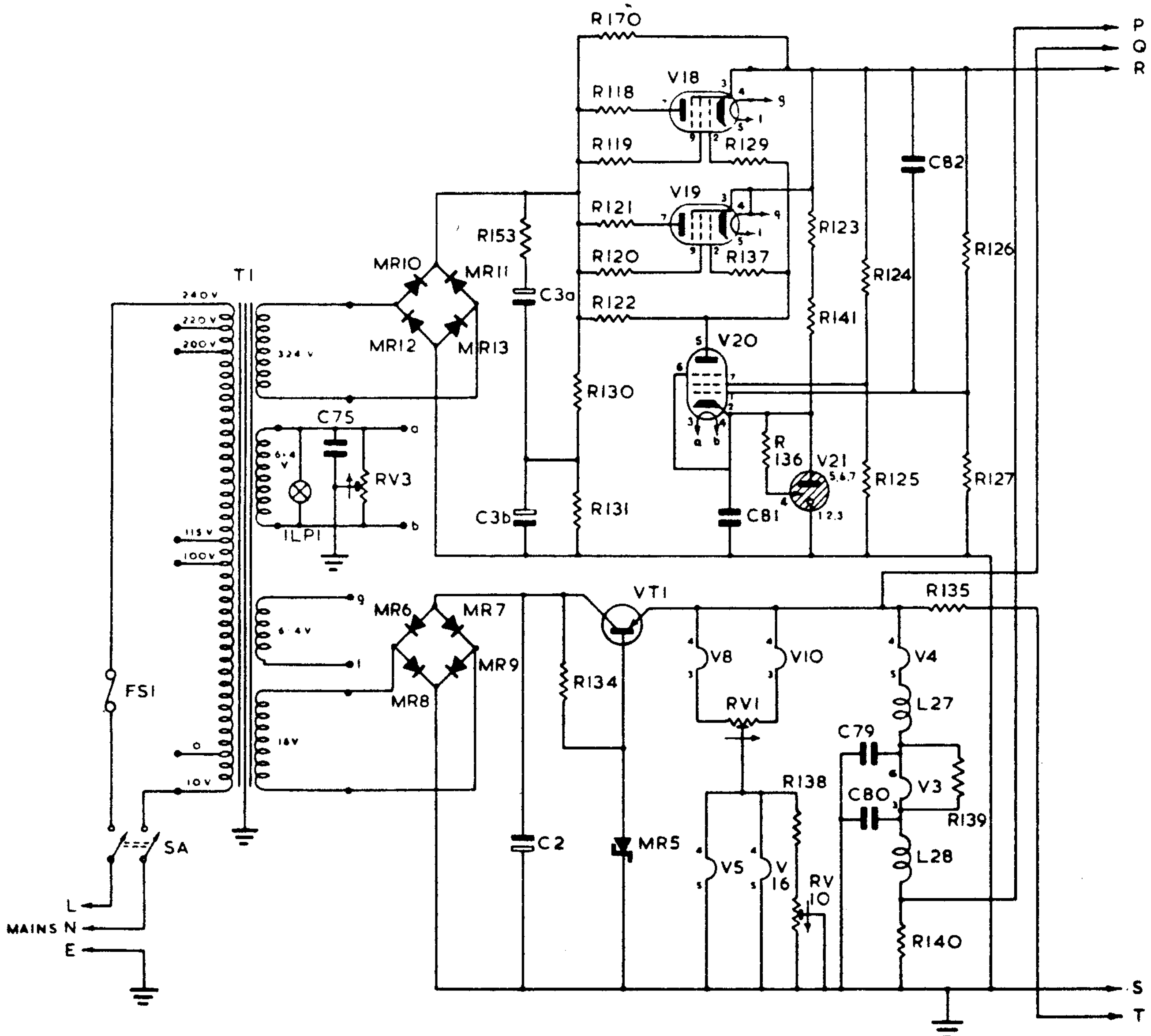


MODULATION METER TYPE 409

CIRCUIT DIAGRAM

FIGURE 2. DRG. No. 6917-101 SHEET 1

ISSUE 13

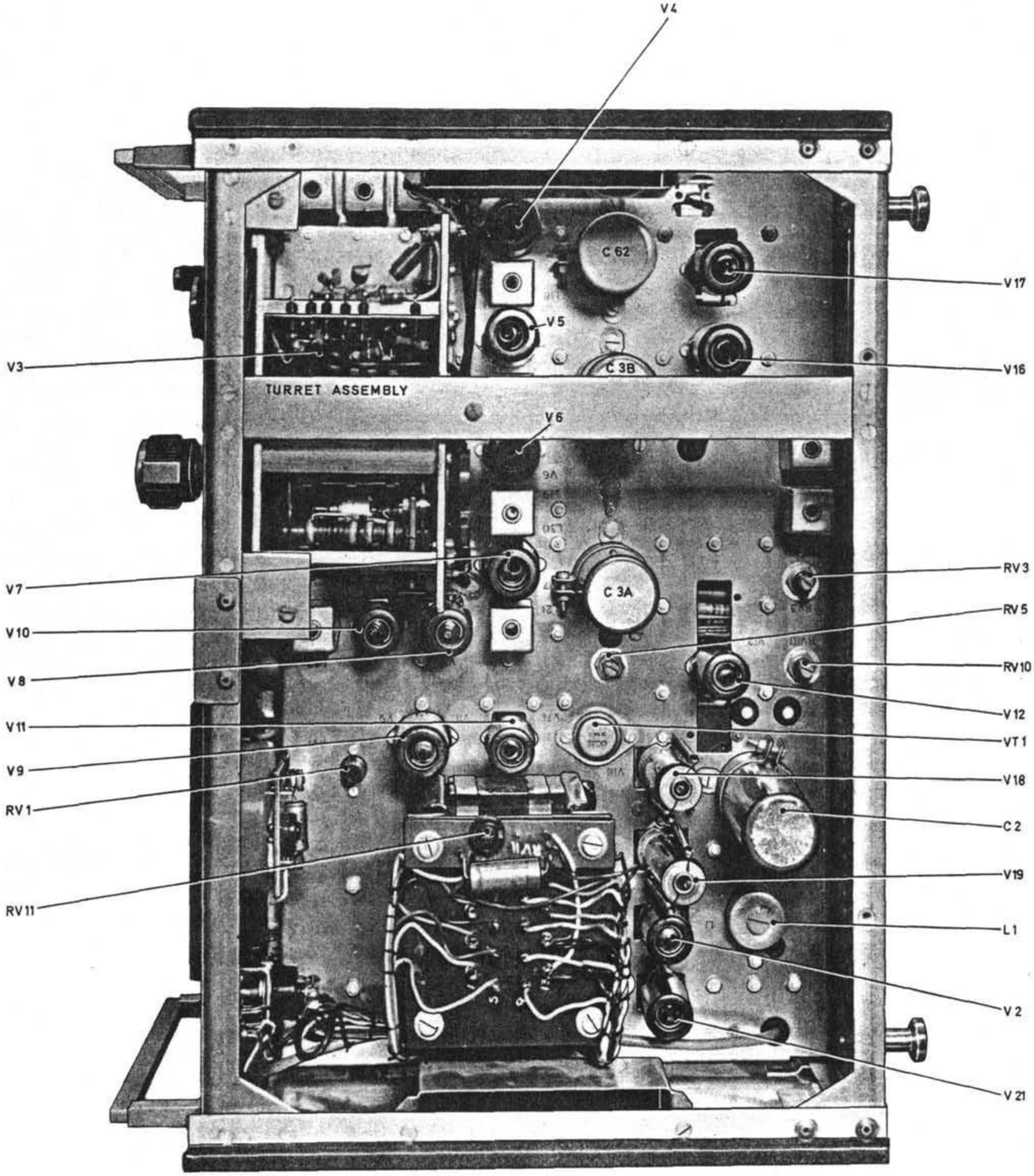


MODULATION METER . TYPE 409

CIRCUIT DIAGRAM

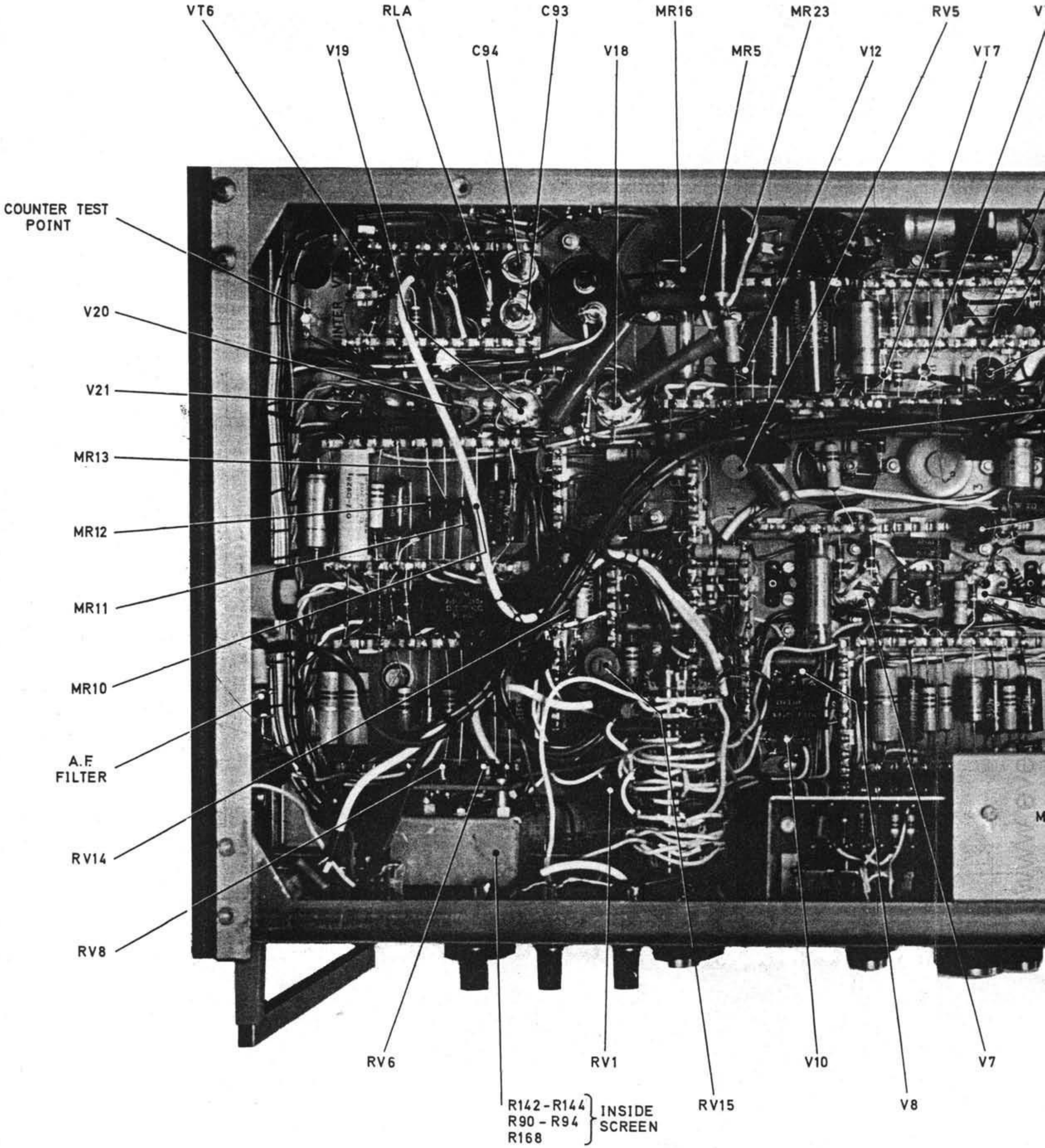
FIG. 3 . DRG. No. 6917-101 . SHEET 2

ISSUE 5

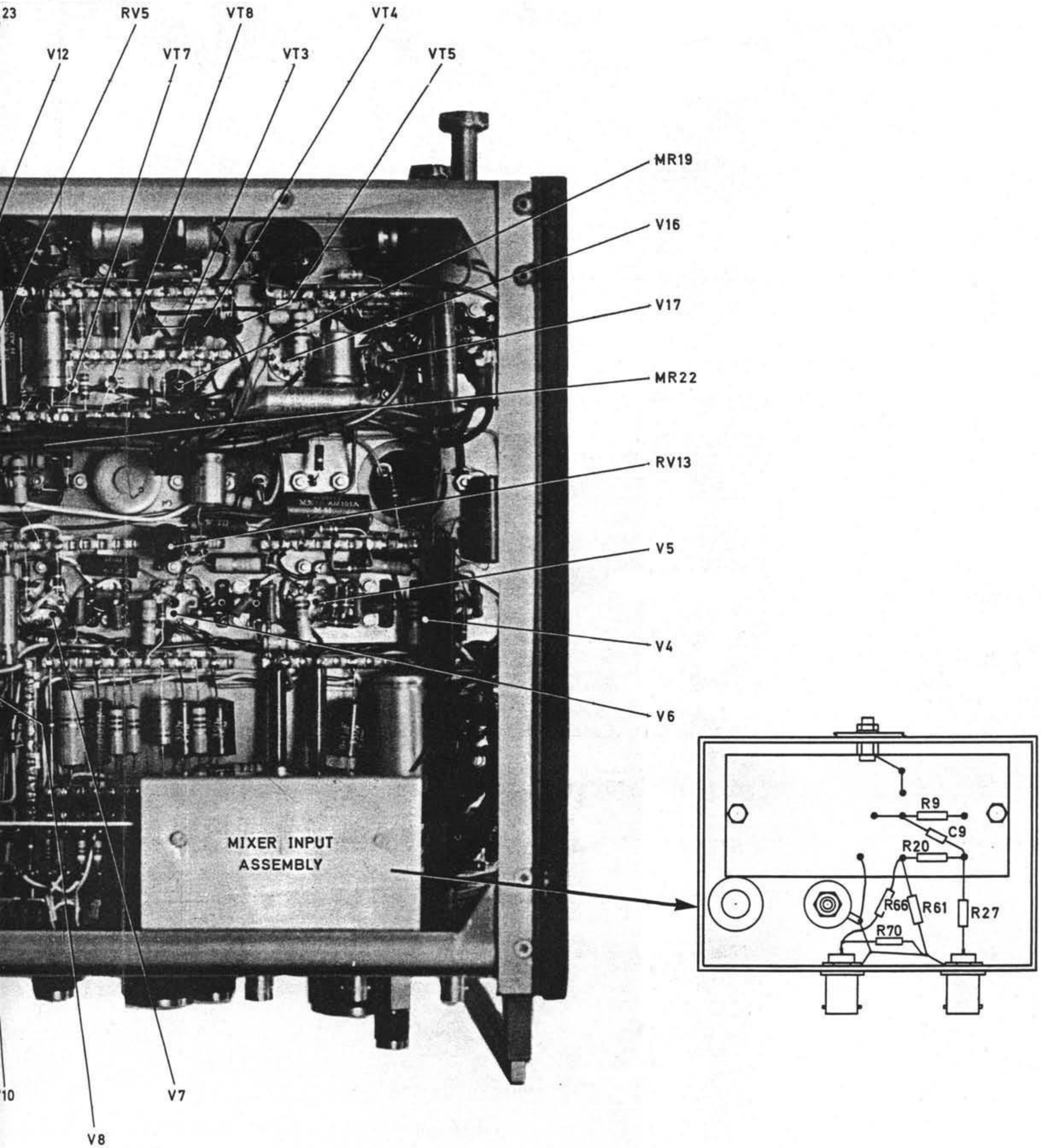


Modulation Meter Type 409
Service View (Upperside)

Fig. 4



Modulation Meter Type 409 : Servi



Type 409 : Service View (Underside)